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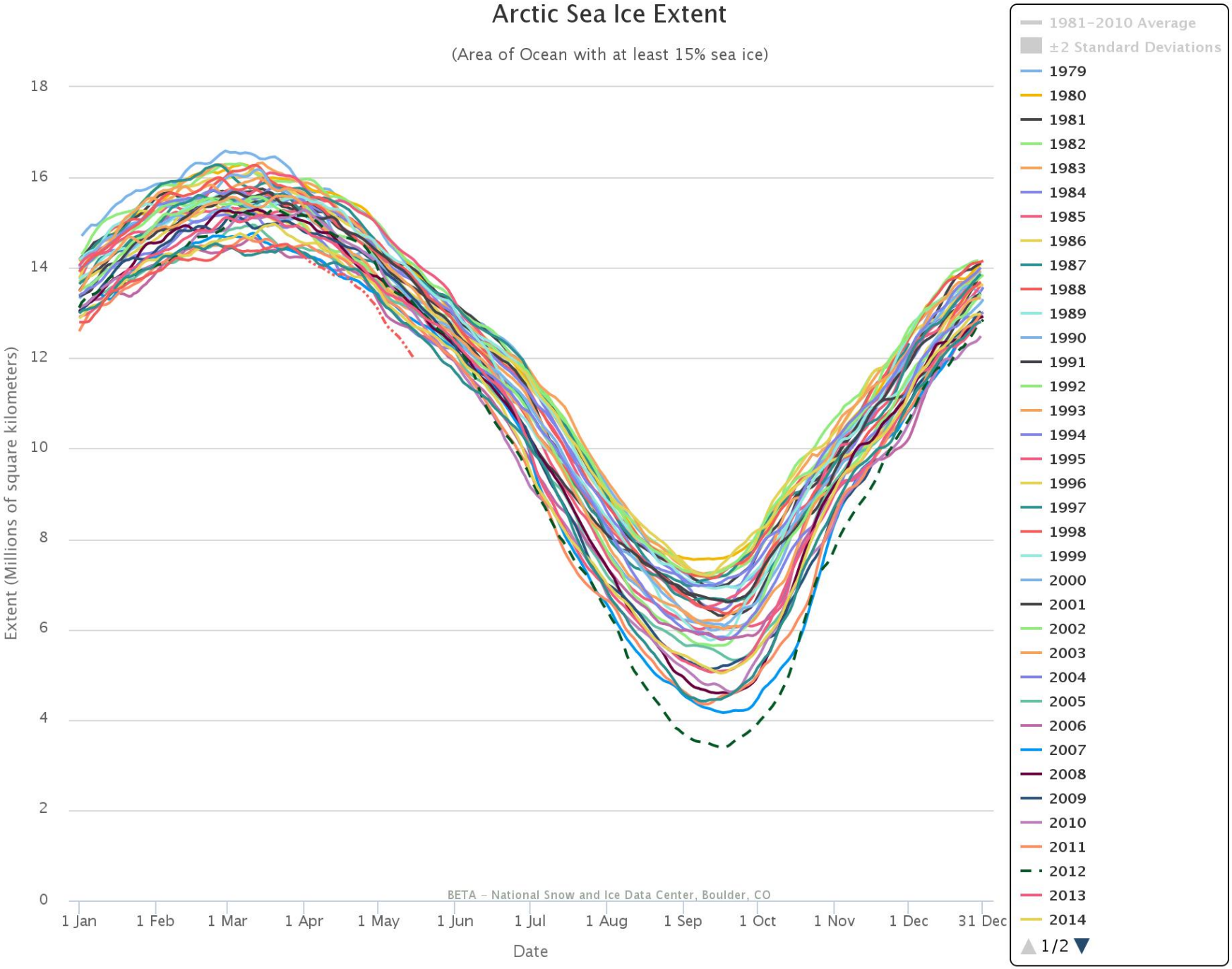
Barcelona Supercomputing Center
Centro Nacional de Supercomputación

EXCELENCIA SEVERO OCHOA

Negative turbulent heat flux feedback

F. Massonnet and J. García-Serrano

Workshop on Feedbacks in Polar Regions
May 17th, 2016


Arctic Sea Ice Extent
(Area of Ocean with at least 15% sea ice)
Extent (Millions of square kilometers)
18
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14
12
10
8
6
4
2
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1 Jan
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1 Mar
1 Apr
1 May
1 Jun
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1 Aug
1 Sep
1 Oct
1 Nov
1 Dec
31 Dec
Date
BETA – National Snow and Ice Data Center, Boulder, CO
1981–2010 Average
±2 Standard Deviations
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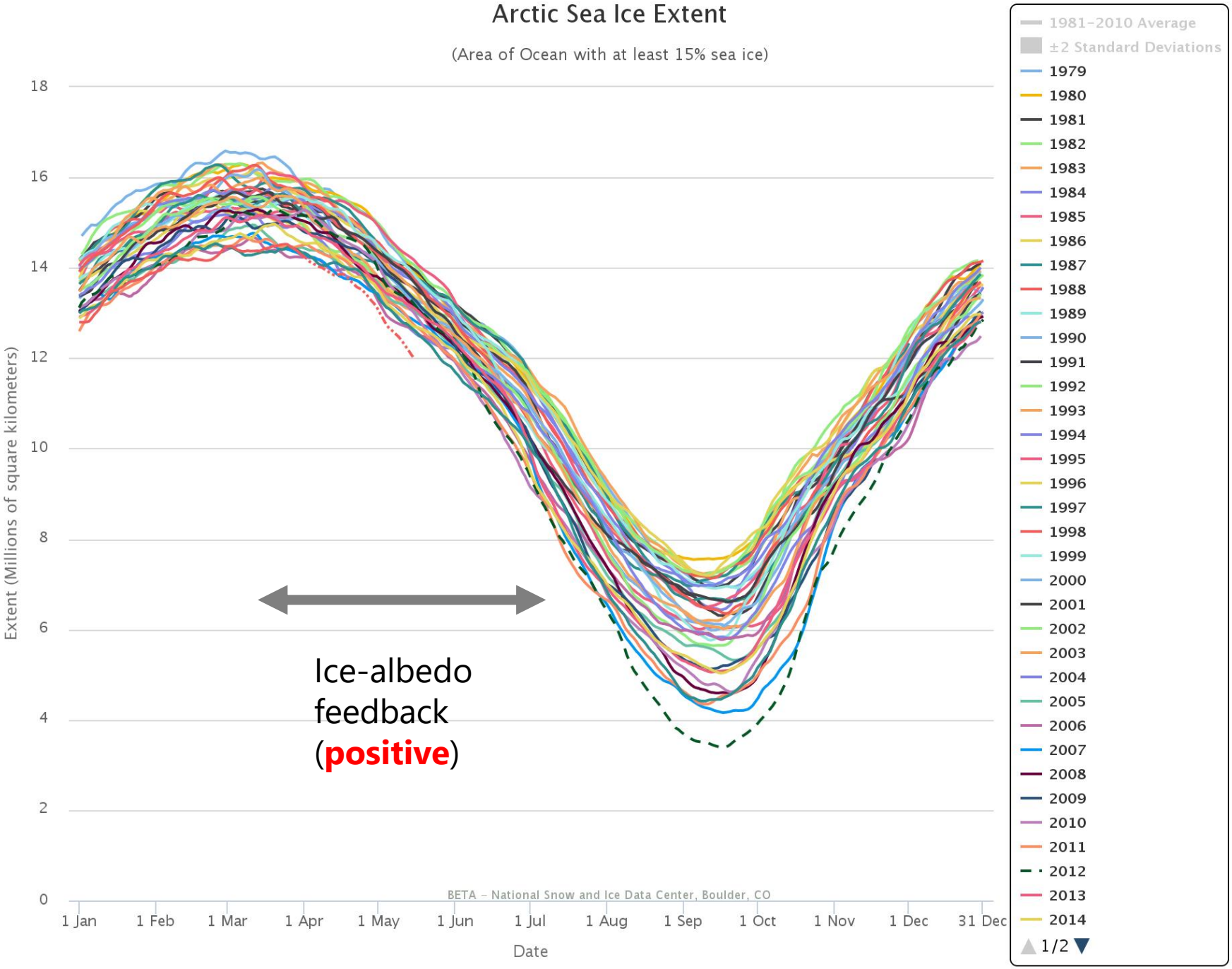
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Ice-albedo feedback (positive)
BETA – National Snow and Ice Data Center, Boulder, CO
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±2 Standard Deviations
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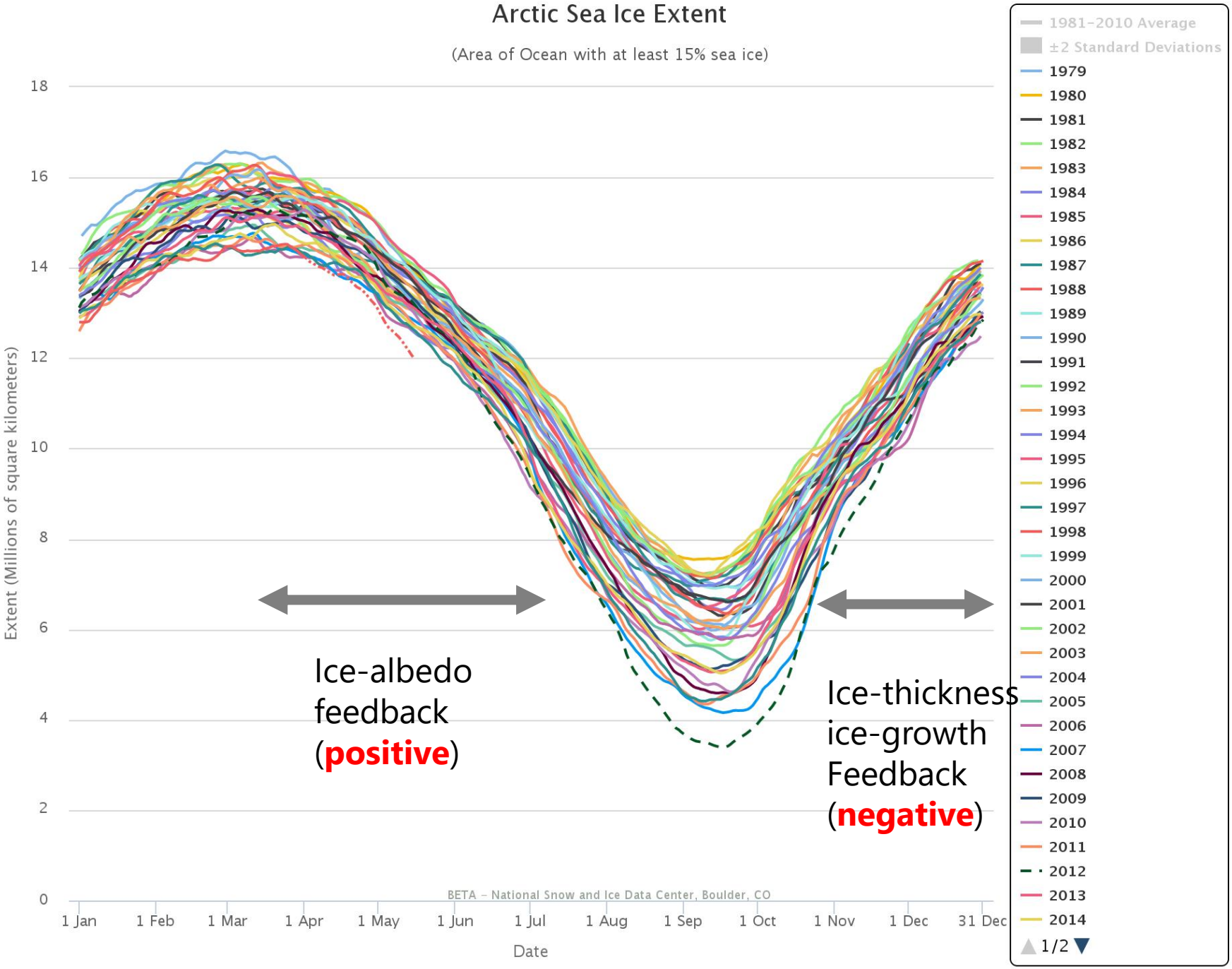
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BETA – National Snow and Ice Data Center, Boulder, CO
Ice-albedo feedback (positive)
Ice-thickness ice-growth Feedback (negative)
1981-2010 Average
±2 Standard Deviations
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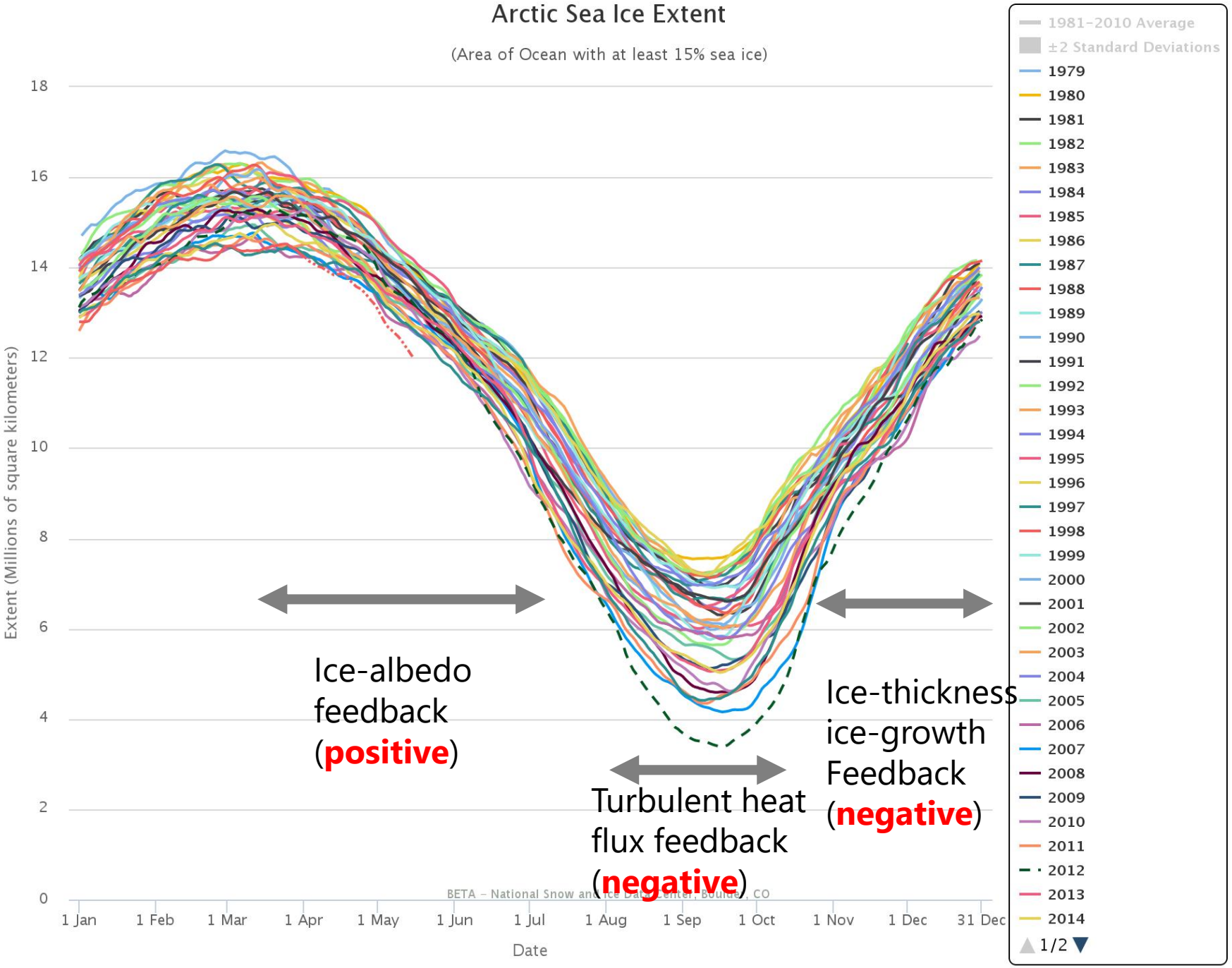
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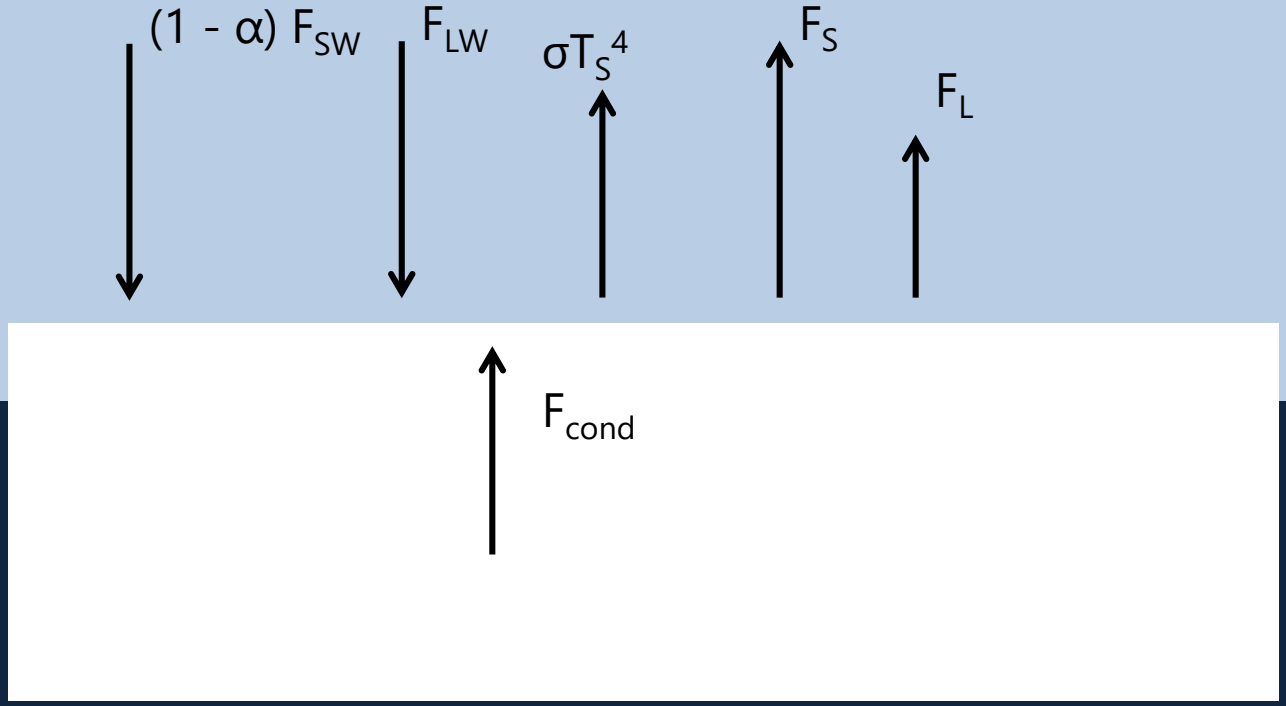
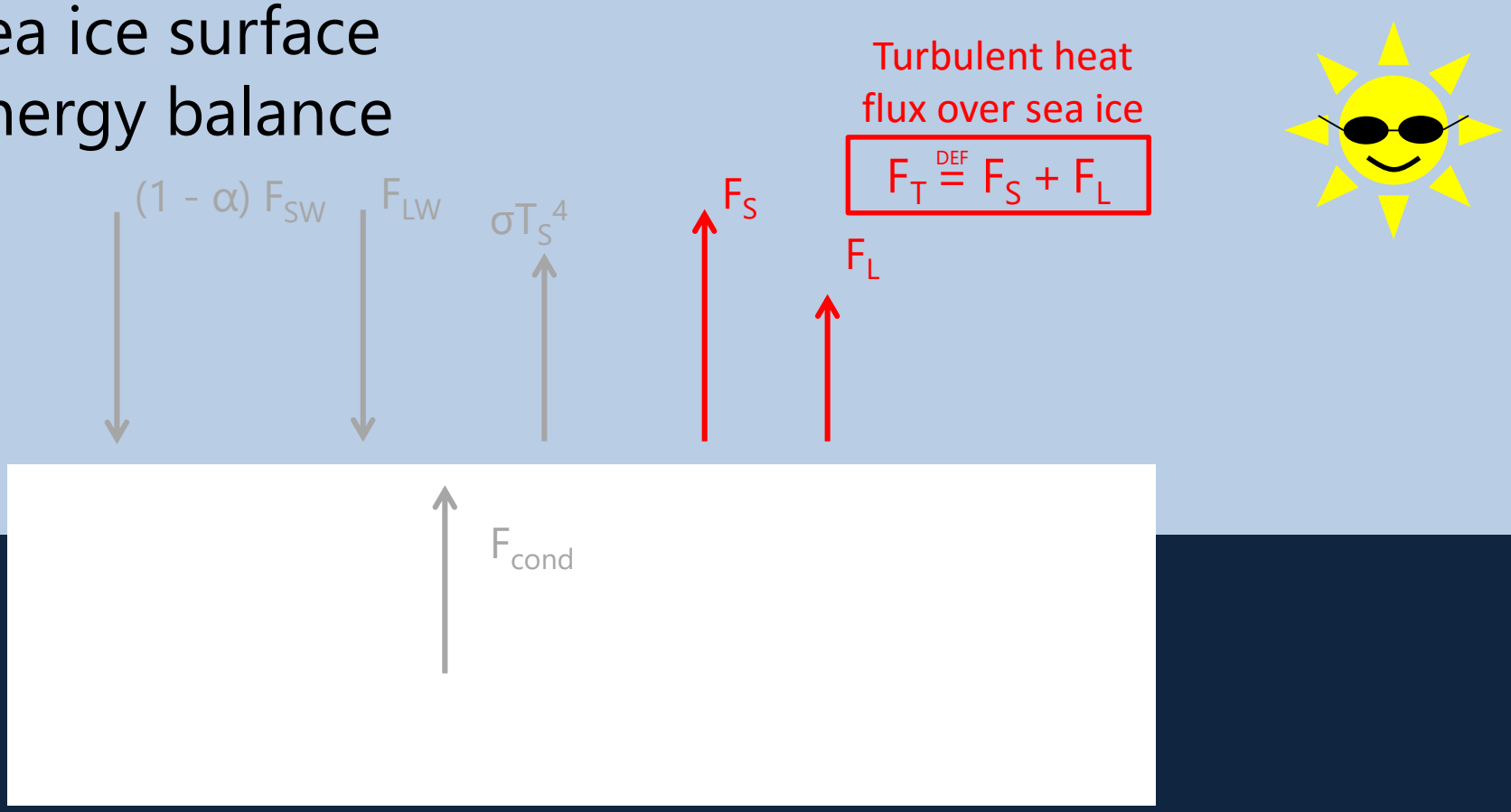
Ice-albedo feedback (positive)
Turbulent heat flux feedback (negative)
Ice-thickness ice-growth Feedback (negative)

Sea ice surface energy balance



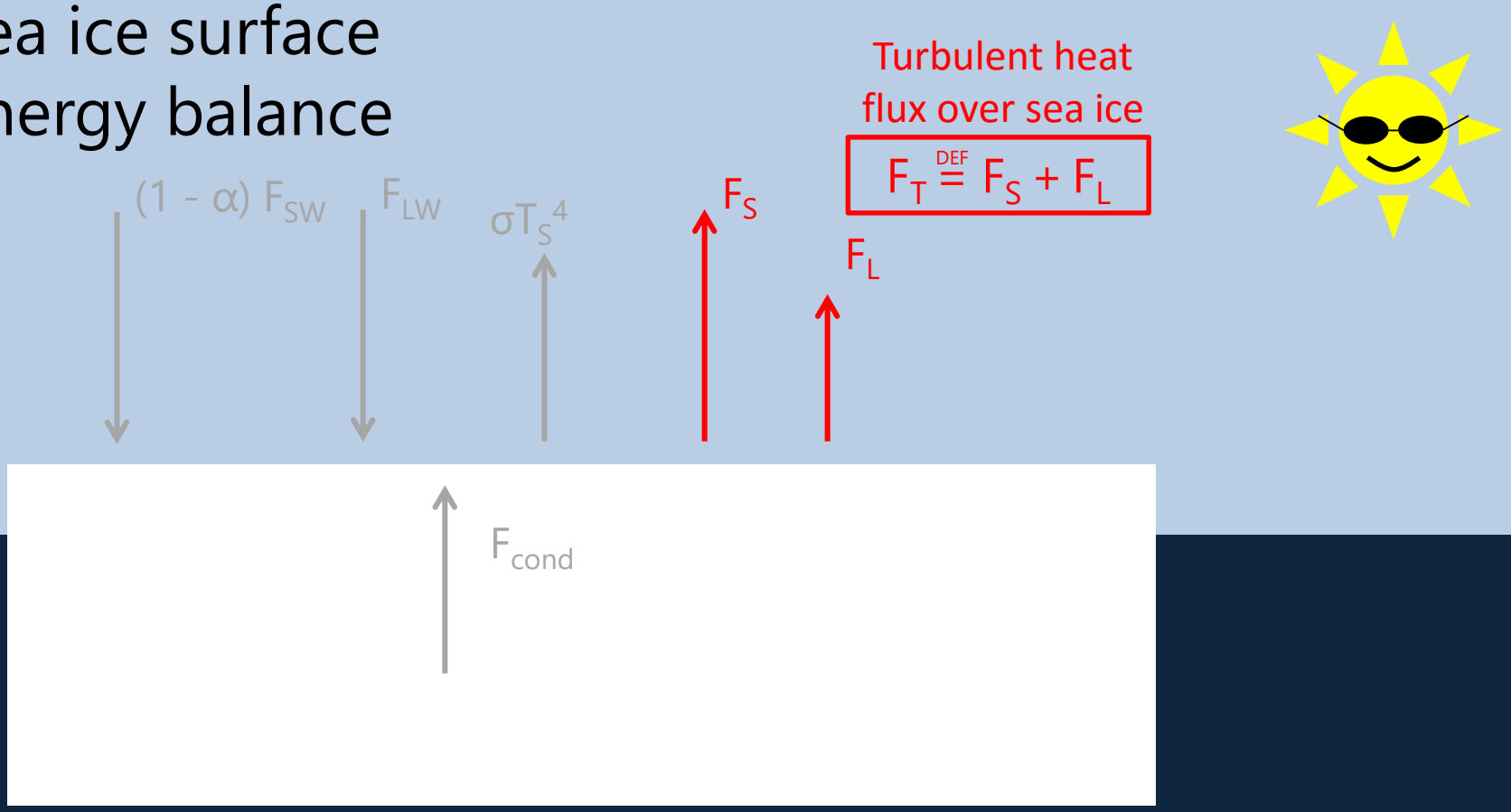
Sea ice surface energy balance



Part 1 – F_T in an atmospheric reanalysis

Part 2 – F_T in an ocean—sea ice model

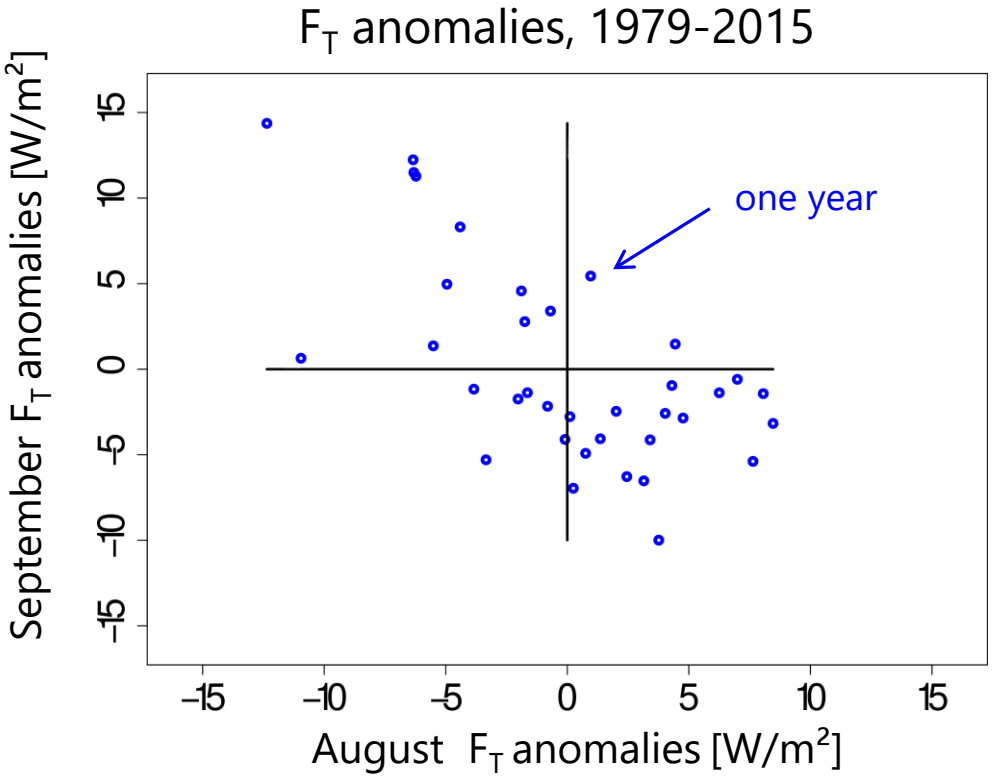
Sea ice surface energy balance

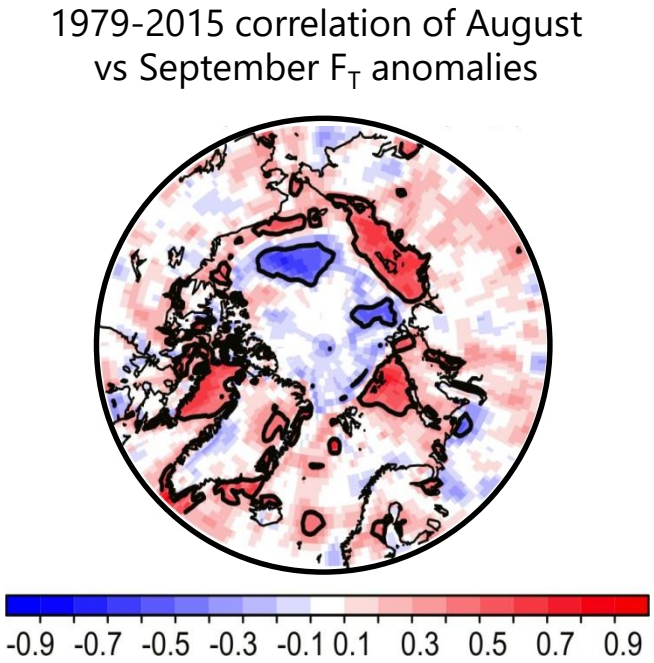


Part 1 – F_T in an atmospheric reanalysis

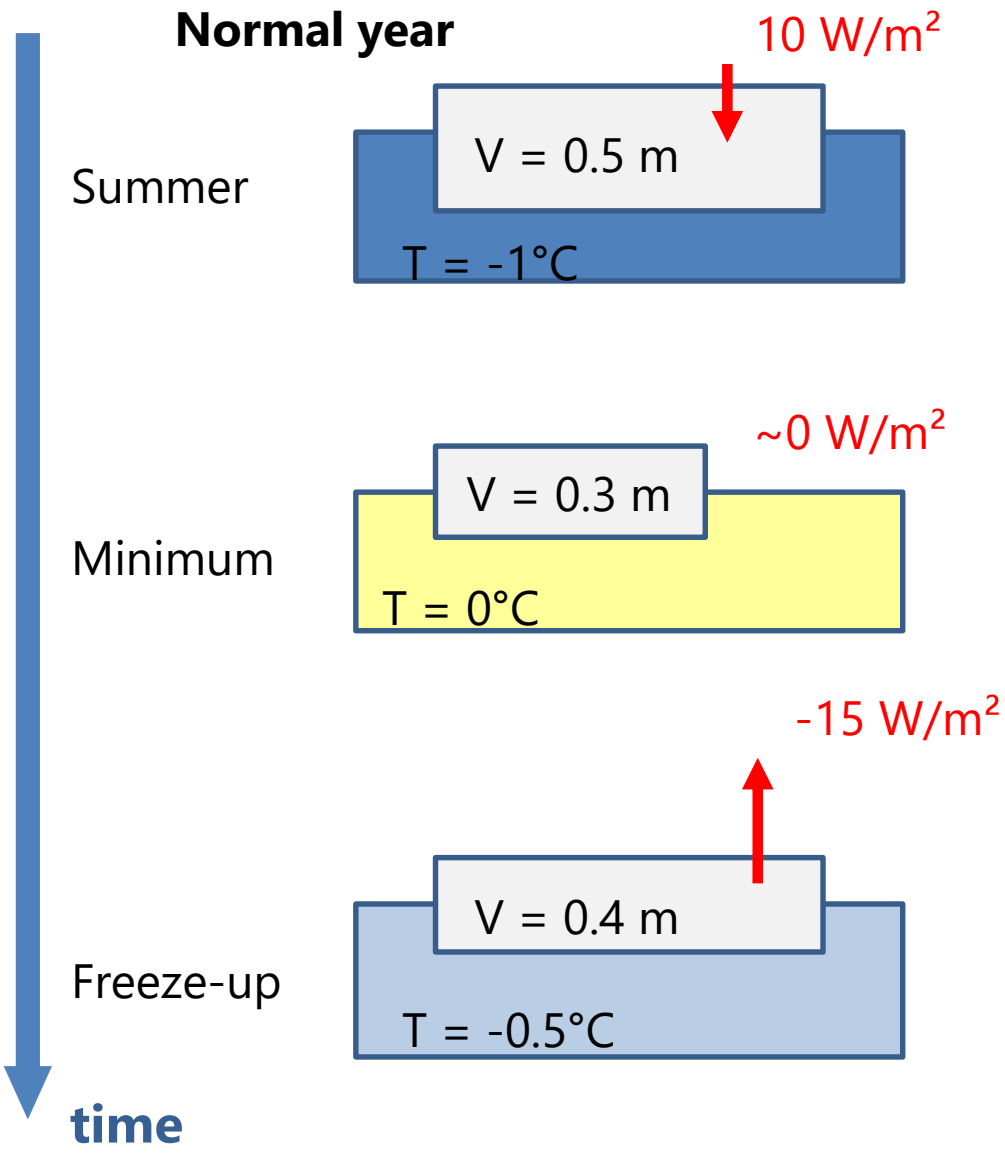
Part 2 – F_T in an ocean—sea ice model

The F_T-feedback is *negative* and can be characterized by the autocorrelation of the F_T





Proposed mechanism: sea ice/ocean as a temporary storage of turbulent heat



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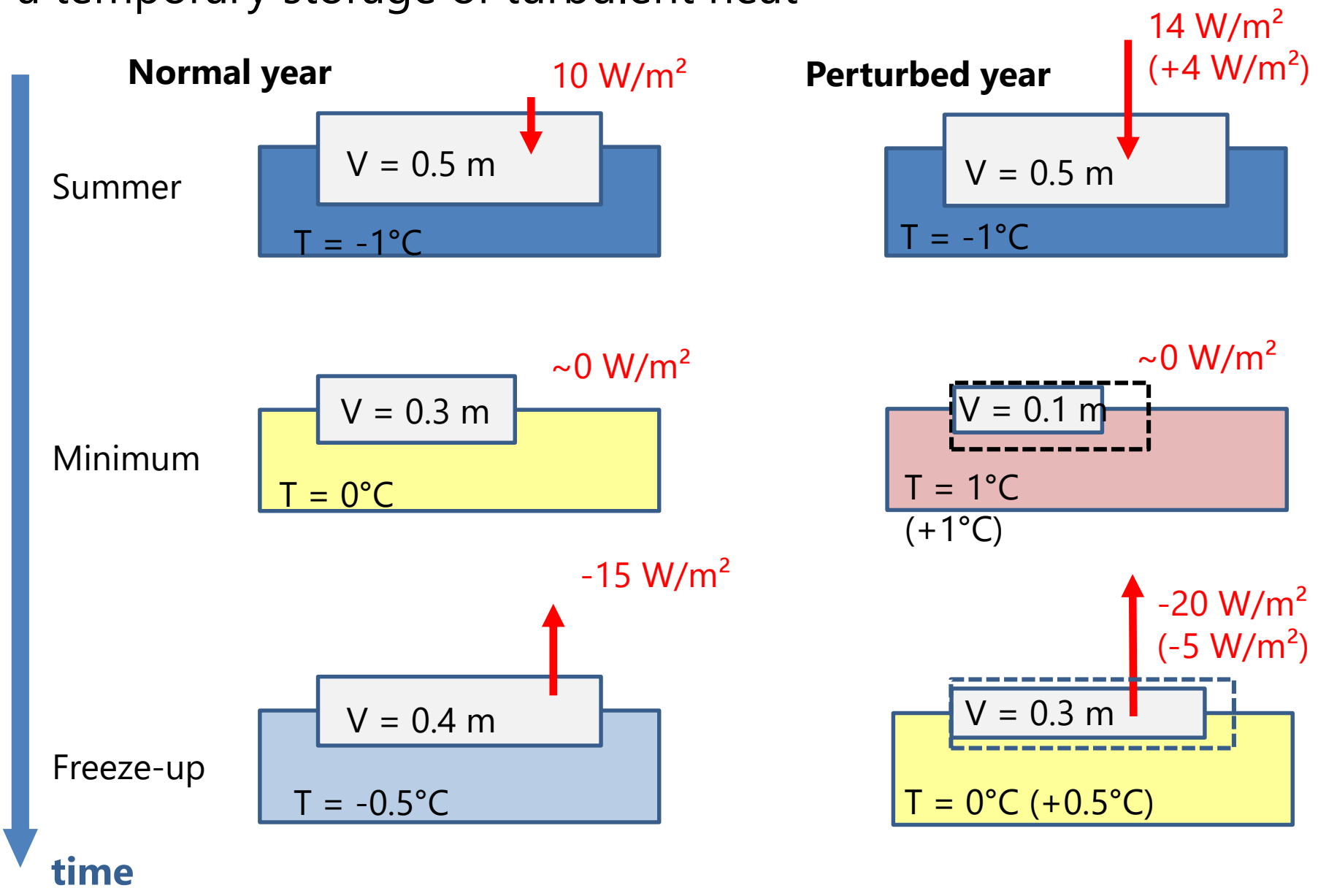

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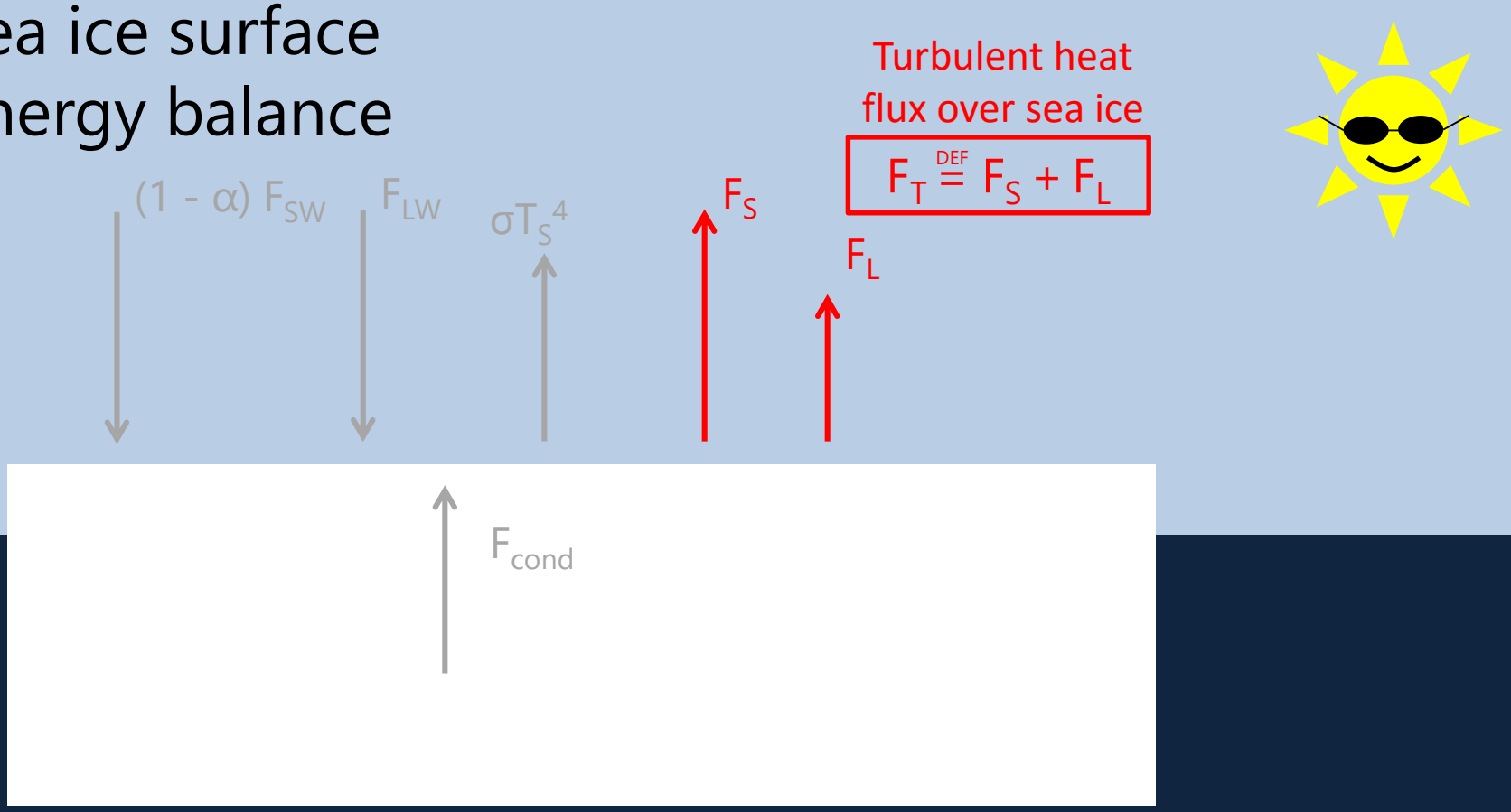

Part 1 – F_T in an atmospheric reanalysis

Part 2 – F_T in an ocean—sea ice model

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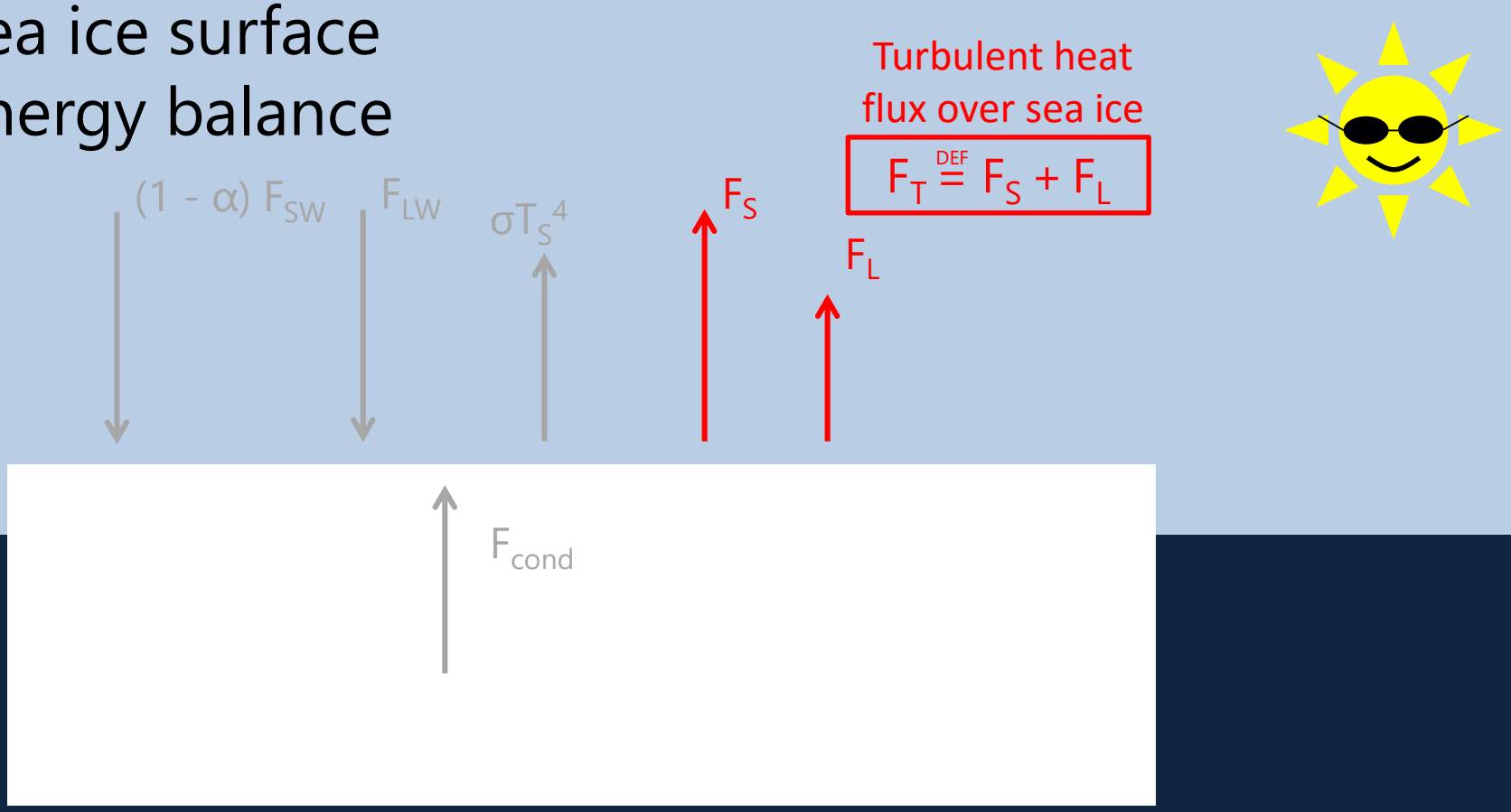


Part 1 – F_T in an atmospheric reanalysis

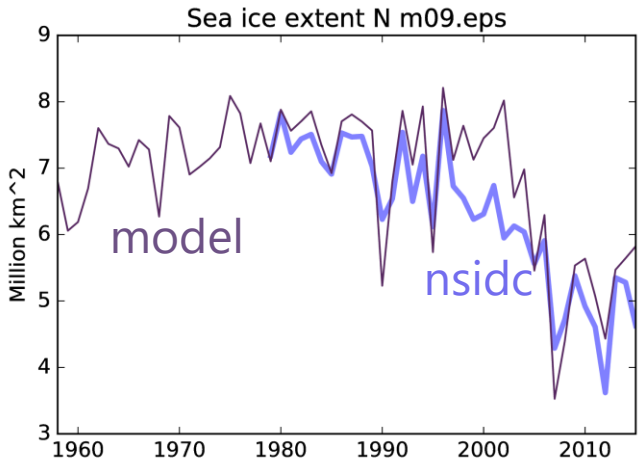
Part 2 – F_T in an ocean—sea ice model

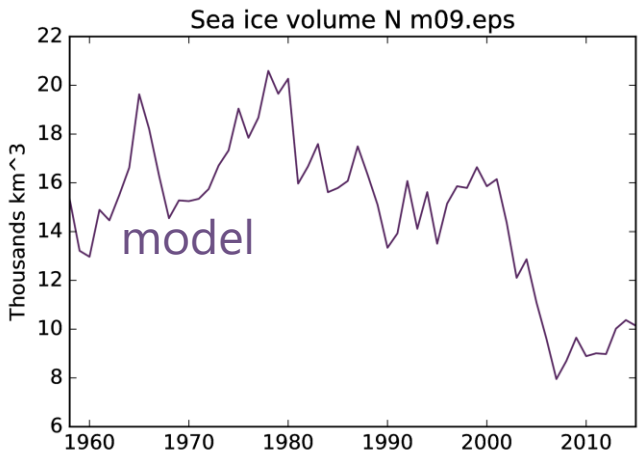
version 3.6 (~CMIP6)

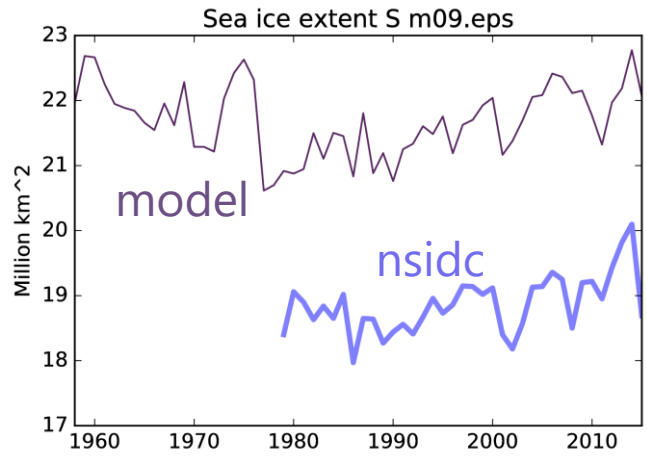
forced by

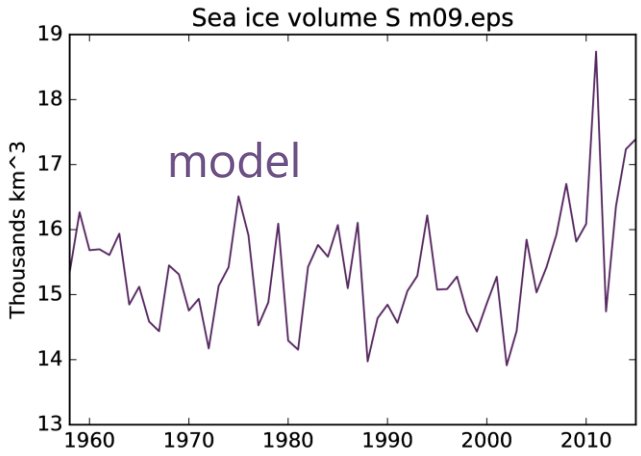
ORCA1 grid (~50 km at the poles)

First order diagnostics for that model: total September sea ice volume and extent



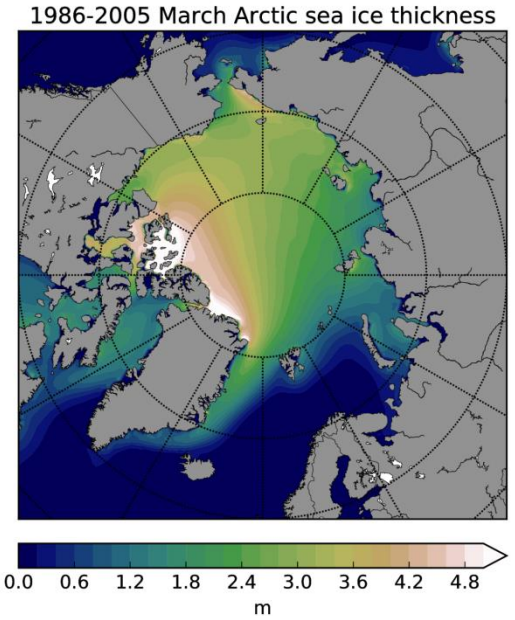


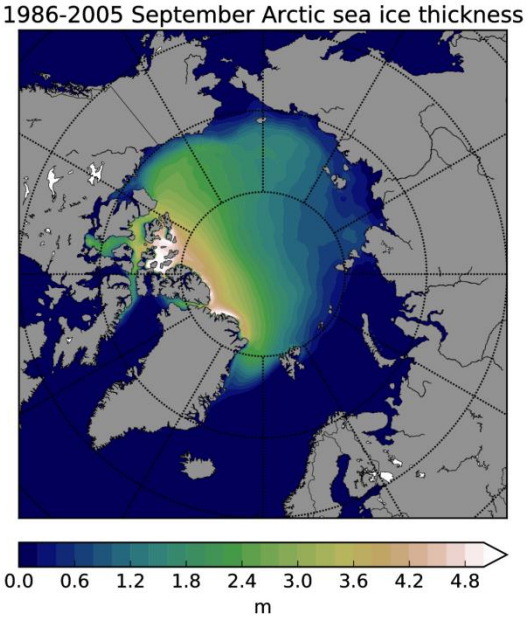


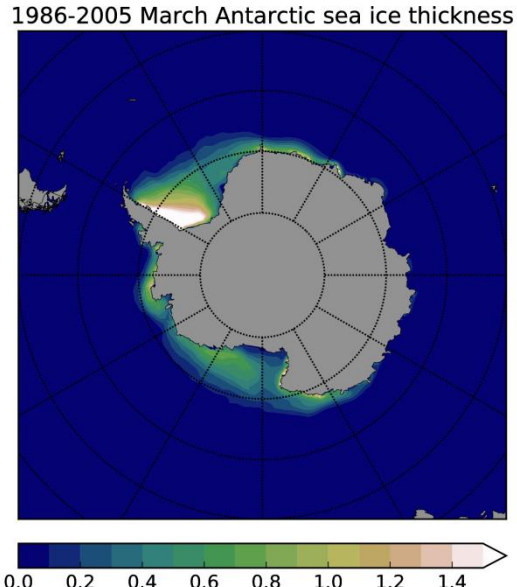


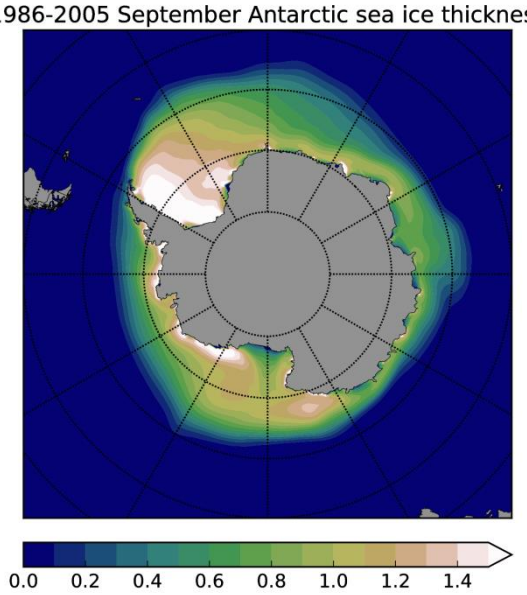
First order diagnostics for that model: sea ice thickness

Ref. period:
1986-2005

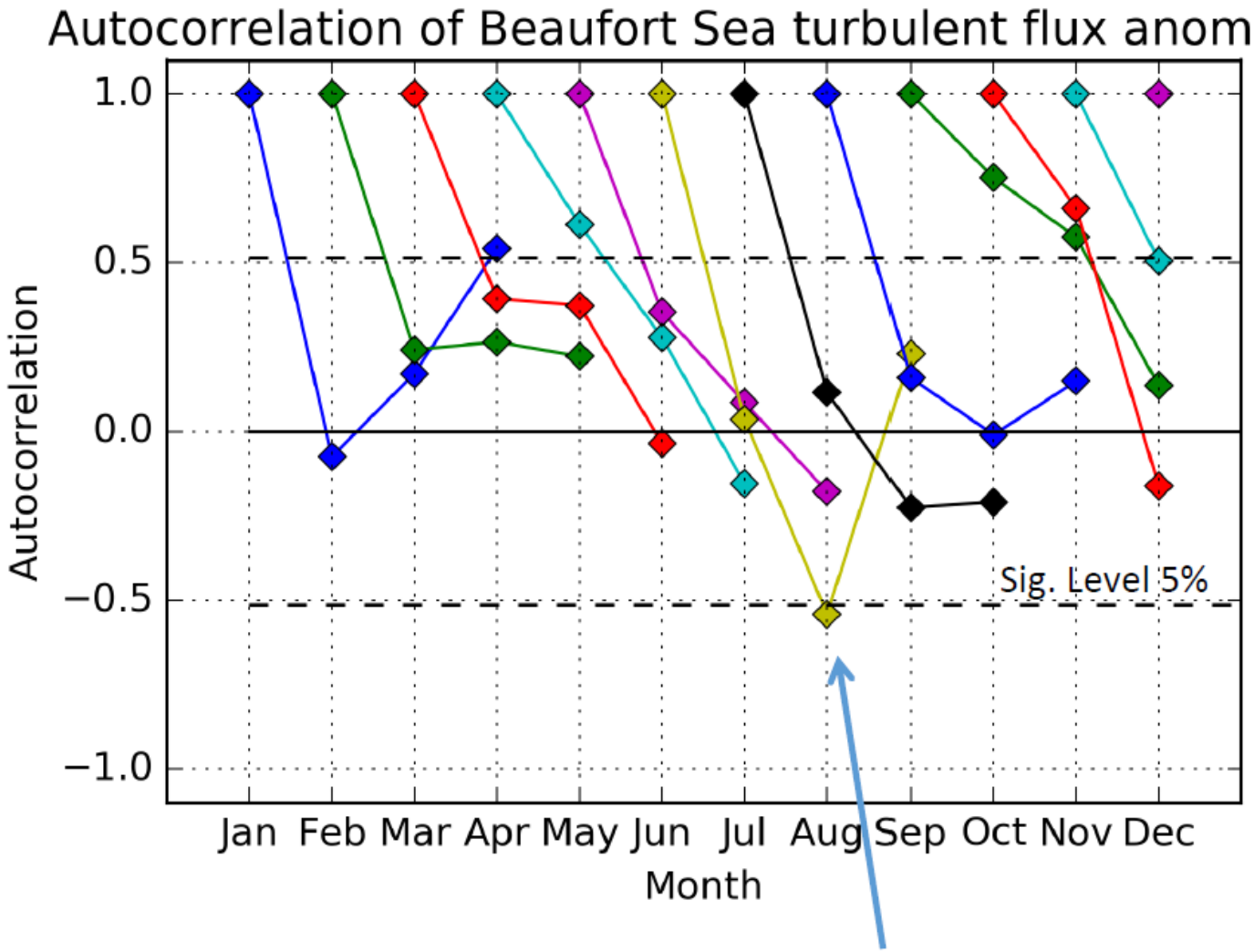








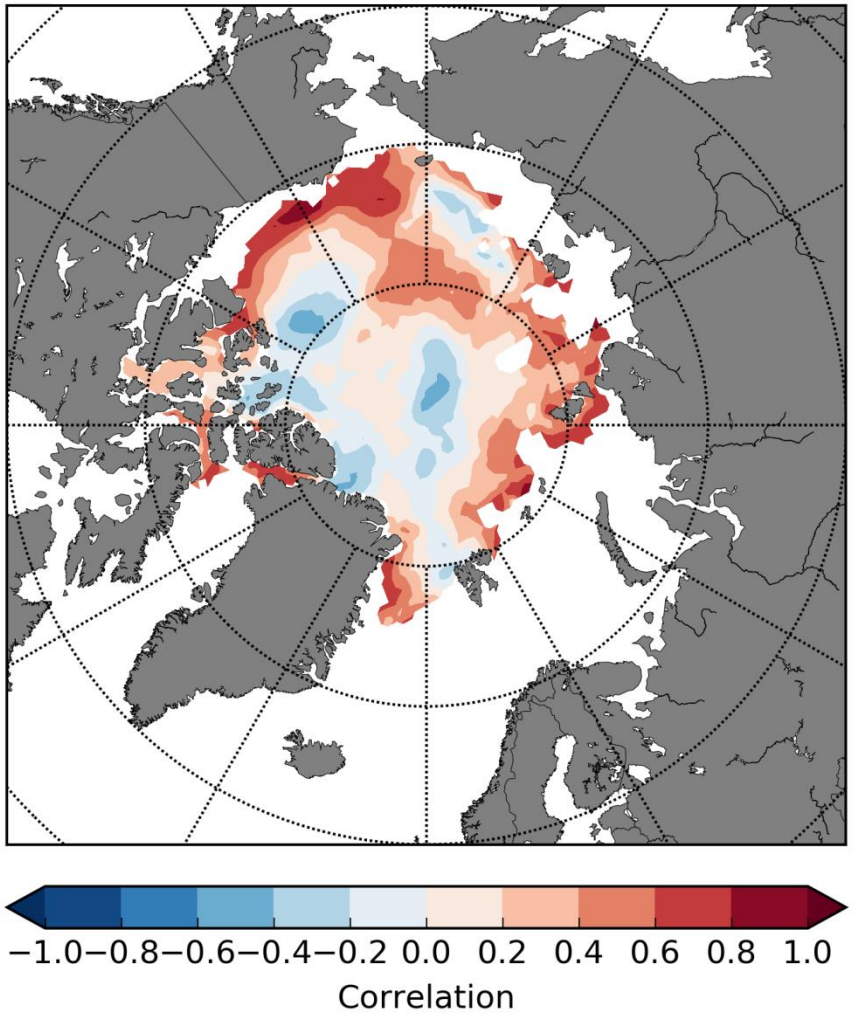
Back to turbulent heat flux diagnostics!



This negative correlation matches the one identified in ERA-Interim, although it happens earlier in the model. And in fact the model is known to reach its minimum about a month earlier than in reality

The model has longer persistence than the reanalysis…

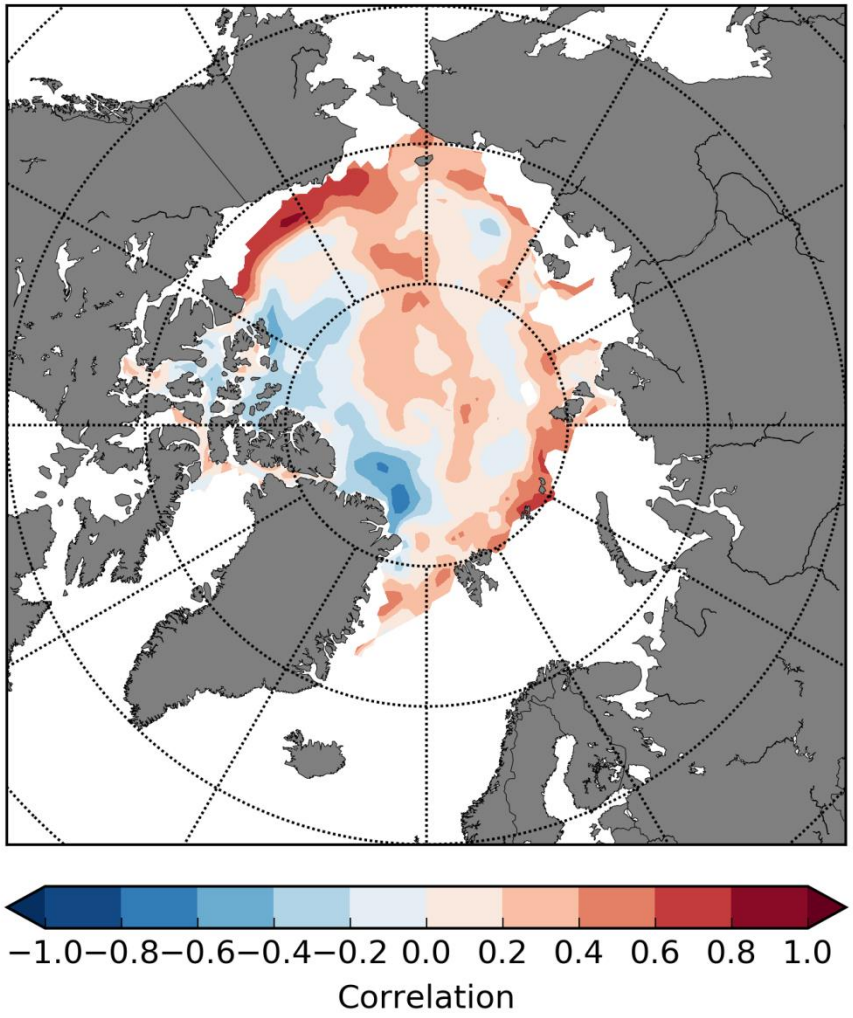
July to August correlation of F_T



Ref: 1979-1999
(simulation is ongoing to output that particular diagnostic!)

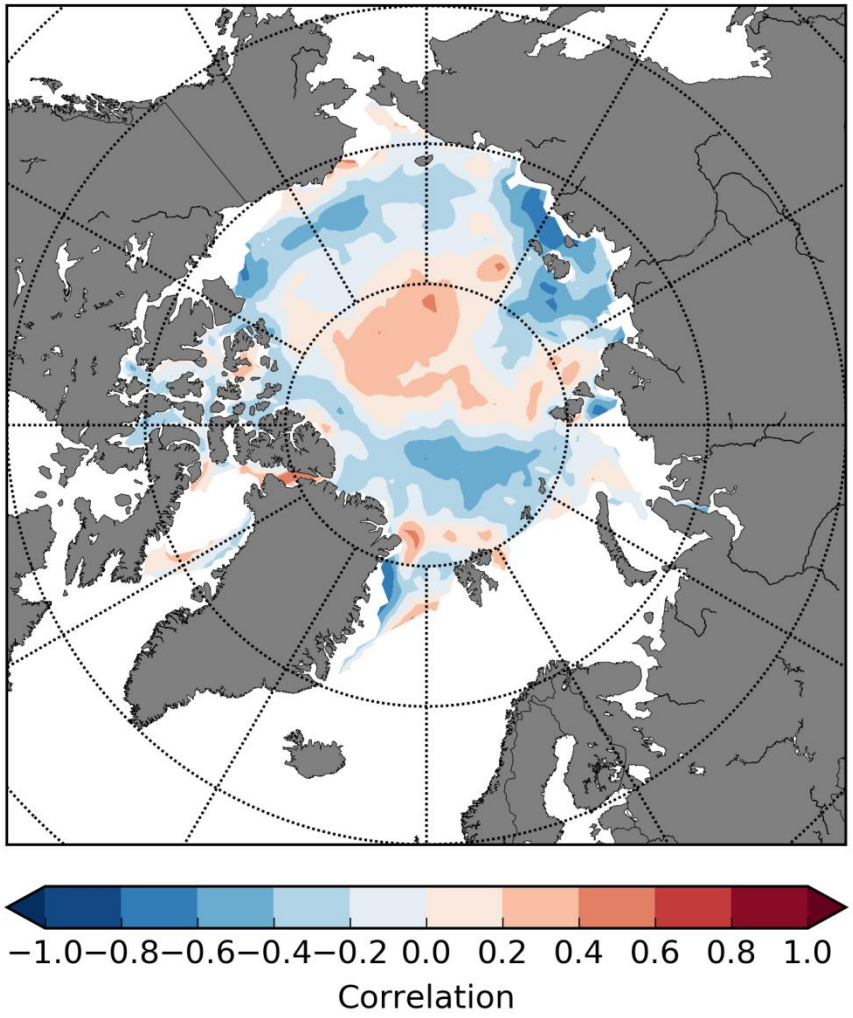
The model has longer persistence than the reanalysis…

July to September correlation of F_T



… but eventually exhibits the same feedback

July to October correlation of F_T



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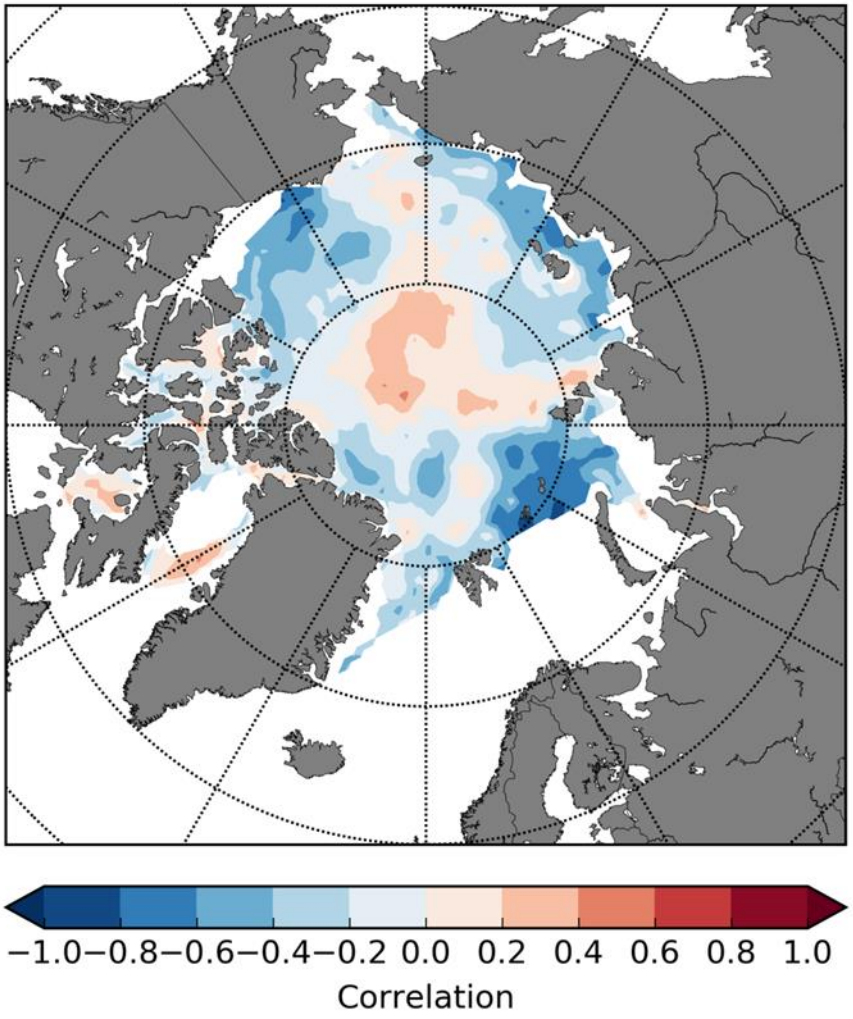
July to November correlation of F_T



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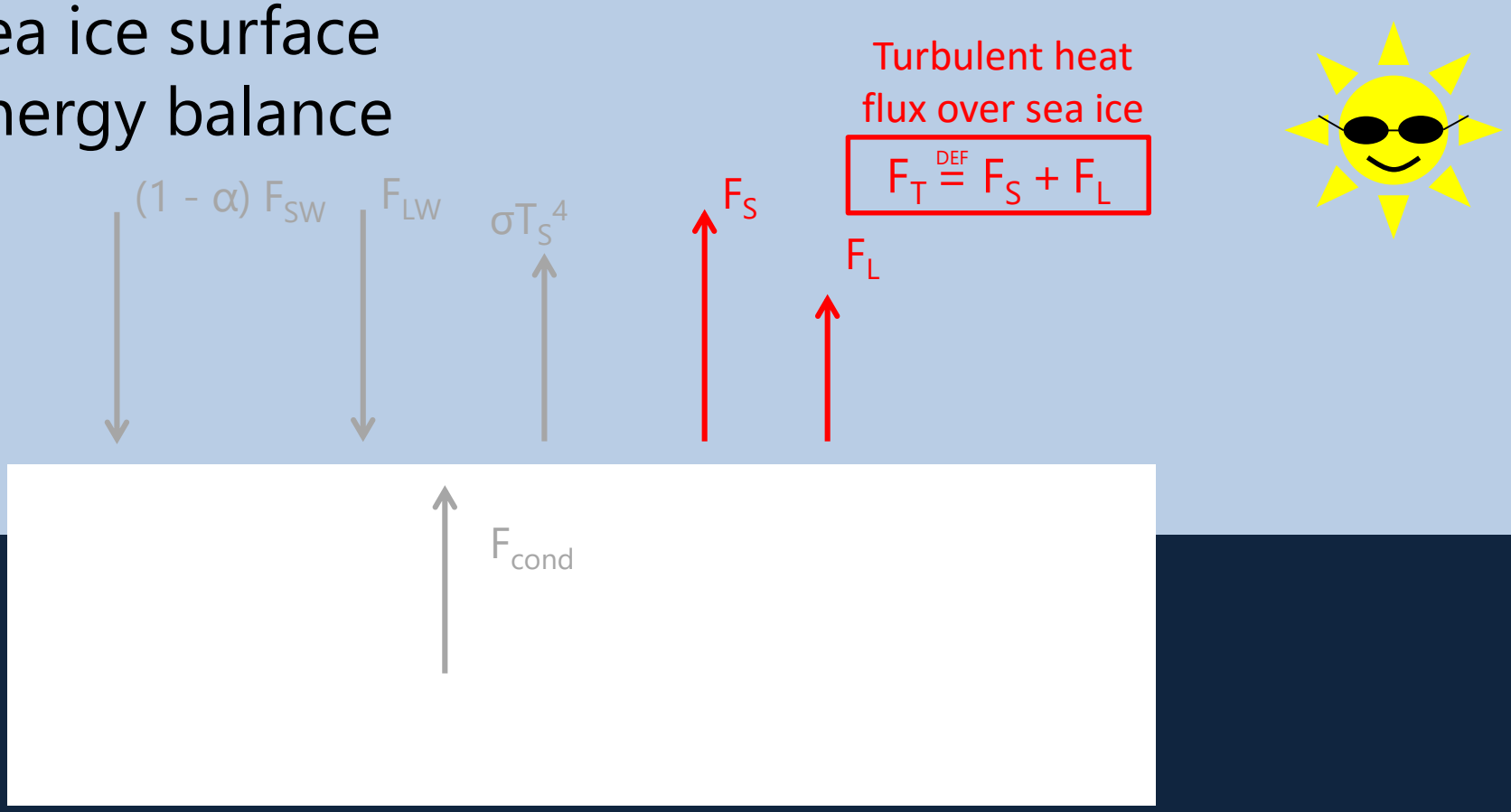

Part 1 – F_T in an atmospheric reanalysis

Part 2 – F_T in an ocean—sea ice model

Conclusions & perspectives

- The Turbulent Heat Flux Feedback is **negative**

Over a year, it competes with the *positive* ice-albedo feedback

- It is a **coupled** atmosphere-ice feedback

The (slow) ice damps anomalies from the (fast) atmosphere

- The feedback is straightforward to **characterize**

It expresses itself as a negative autocorrelation in F_T heat flux

- It is seen in a **reanalysis** and an ocean-sea ice **model**

Is it also present in coupled models?

- Also seen in a **low-order sea ice model**?

A feedback is robust if it is independent of model complexity

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Thank you

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